LOCAL ATMOSPHERE SALT PROFILE

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DETERMINATION OF TRACE CONCENTRATIONS OF SODIUM CHLORIDE IN THE ATMOSPHERE

INTRODUCTION

During pre-launch checkout and testing, the vehicle and spacecraft are positioned for extended periods on the launch pads which are located approximately 1/2 mile from the ocean. Sodium chloride and other salts in seawater which exist in the atmosphere as an aerosol are corrosive and could initiate or accelerate the decay and deterioration of critical GSE and flight components. This study was initiated to measure these constituents in the atmosphere at various elevations and distances from the ocean. The Kennedy Space Center 150 Meter Ground Winds Tower located approximately 3 miles from the ocean was used to obtain inland samples at ground level and at elevations of 30, 60, 90, and 120 meters. Complex 39, Pad B, located approximately 2500 feet from the ocean, was utilized as the ocean-front site. Samples were taken either from the LUT at the 0, 100, 220, 300, and 360 ft. levels or from the MSS at the 130, 230, and 340 ft. levels.

Aerosol samples were taken twice daily for a three-month period from each of the above locations. Concurrent with each series of aerosol samples, meteorological data was obtained from the Kennedy Space Center 150 Meter Ground Winds Tower.

In addition to the aerosol sampling, pans containing deionized water and stainless steel plates were placed at each location in order to obtain data on salt fallout.

The composition of seawater, which is felt to be the source of atmospheric salt in coastal areas, is shown in the following table.

TABLE I

IONIC COMPOSITION OF SEAWATER [1]

Ions	g/kg Seawater
SO_4	2.6486
Cl	18.9799
Ca	0.4001
Mg	1.2720
Na	10.5561
K	0.3800
Sr	0.0133
HCO_3	0.1397
Br	0.0646
F	0.0013
H_3BO_3	0.0260
Total Solids	34.4816
Water	965.5184
TOTAL	1000.0000

[1] Technical Data Book, Office of Saline Water, dated 10-60.

Results shown in this report were obtained by analyzing for sodium and conversion to sodium chloride. Data given in Table I indicate that corrections should be applied if results in terms of total atmospheric solids are desired.

CONCLUSIONS

The following conclusions are based on information presented in subsequent portions of this report.

1. Salt is present in the local atmosphere under all weather conditions. Average aerosol concentrations ranged from 1.7 to 9.8 μg $NaCl/M^3$.
2. East winds produce the highest average aerosol salt concentration (5.8 μg $NaCl/M^3$); west winds, the lowest (2.2 μg $NaCl/M^3$).
3. Aerosol data from wind speeds greater than 4.5 M/sec averaged 4.7 μg $NaCl/M^3$, while lower wind speeds produced an average salt concentration of 4.2 μg $NaCl/M^3$.
4. Aerosol samples taken close to the ocean at Complex 39, Pad B, show a higher average salt concentration (5.4 μg $NaCl/M^3$) than aerosol samples taken at the Kennedy Space Center 150 Meter Ground Winds Tower (3.6 μg $NaCl/M^3$).
5. Ground level salt concentrations averaged 4.8 μg $NaCl/M^3$, and the salt concentration at 120 meters averaged 4.6 μg $NaCl/M^3$.
6. Samples taken during a heavy fog contained much higher concentrations of salt than preceding and following samples taken during clear conditions.

7. A single aerosol sample taken inside the VAB at the 90' level in the Northeast High Bay showed 5 μg $NaCl/M^3$. This sample was taken with the bottom door open and under conditions of an east wind >4.5 M/sec.

8. Salt fallout on a dry horizontal surface averaged 134 μg $NaCl/M^2/hr$, calculated from the data in Tables XX and XXI, and ranged from 43 μg $NaCl/M^2/hr$ to 260 μg $NaCl/M^2/hr$.

Atmospheric sampling on a limited basis will be continued for the remainder of the year to determine if seasonal variations of any magnitude exist. A supplementary report will be issued if the data warrants.

EXPERIMENTAL

SAMPLING

A. AEROSOL - Aerosol samples were taken with a 37 mm diameter, 0.45μ, type HAWP membrane filter contained in an acrylic aerosol field monitor. The filter was placed in a vertical position at the designated elevation and a flow of ∿15 L/min for two hours passed through it. The filter was then placed in a beaker containing 10 ml deionized water. The water solution was analyzed for sodium by atomic absorption and the sample results were expressed as μg $NaCl/M^3$. Appendix I details the tests validating the suitability of filter pads for salt aerosol monitoring. Appendix II shows the individual aerosol data. No attempt was made to correct for wind changes which occurred during the test period or for possible shielding effects by structures at the sampling points.

B. FALLOUT - One square foot stainless steel pans containing deionized water and one square foot stainless steel plates were exposed for periods ranging from one hour to six days at the same locations where the aerosol sampling was performed. Prior to placing a plate on the structure one technician wearing plastic gloves held the plate in a vertical position while a second technician rinsed it with deionized water and wiped it with tissue paper. The pans were given identical treatment except that following the rinse and placement on the structure, 300 ml of deionized water was added to each pan. At the conclusion of the sampling period water from each pan was transferred to a sample bottle along with a subsequent flush. An exposed plate was held vertically over a catch pan and the surface thoroughly flushed with deionized water. This water was transferred to a sample bottle, the pan flushed and the flush water added to the plate sample bottle. The plate was then placed inside a plastic bag and left until the next test. Trial runs in the laboratory indicated that there was no measurable contamination introduced by using this sampling procedure.

Appendix III describes the various developmental tests carried out in connection with the fallout studies and presents the data obtained under various test conditions.

CHEMICAL ANALYSIS

Atomic absorption spectrophotometry was selected as the analytical method because of the limited amount of preparation and handling required and because of the ease with which samples can be processed. All analyses were specific for sodium. Comparison data obtained between the atomic absorption spectrophotometer and the laboratory colorimetric analysis for chloride are shown in Table II.

CHEMICAL ANALYSIS (Cont'd)

TABLE II

COMPARATIVE ANALYSIS OF CHLORIDES AND SODIUM

μg Chloride Determined Colorimetrically	μg Equivalent Sodium in Seawater*	μg Sodium Determined by Atomic Absorption
288	158	156
858	471	450
690	379	384
552	303	372
798	438	432
324	178	168
252	138	132
336	185	162
342	188	156
294	162	138

*Office of Saline Water, Technical Data Book, Table OWS 2.0, dated 10-60.

The atomic absorption determination appears to be slightly lower than the colorimetric analysis; however, the difference is not statistically significant. These analyses were performed on fallout samples taken at Complex 39, Pad B.

APPENDIX I

Aerosol Method Development

To establish the efficiency of the membrane filter method several tests were conducted to answer the following questions:

A. Can airborne NaCl be effectively trapped on a membrane filter?

B. What pore size would be most effective?

C. Would NaCl crystals migrate through the membrane?

D. What flow rates would be optimum?

E. Could trapped NaCl be quantitatively removed by deionized water?

Laboratory data were obtained using a particle generator containing a synthetic seawater which was aspirated into a controlled drying air flow. Samples were taken downstream of the generator and analyzed for sodium on an atomic absorption spectrophotometer. The synthetic solution contained the following:

$NaCl$	-	25 g/L
$MgCl_2$	-	5 g/L
Na_2SO_4	-	4 g/L
$CaCl_2$	-	1 g/L

Test 1

Test 1 consisted of taking 100 liter samples at 10 L/min through 0.45μ membrane filters to determine the feasibility of utilizing the particle generator as an aerosol source. The test was also intended to determine if salt particles are retained by the filter and if they can be readily dissolved in water for subsequent analysis by atomic absorption. The results are shown in Table III.

TABLE III

CONCENTRATION OF SODIUM CHLORIDE IN PARTICLE GENERATOR EFFLUENT

Run	μg NaCl/M^3
1	3251
2	3683
3	2870
4	5486
5	4750
6	4115
7	3658

Additional samples were taken by placing membrane filters in a parallel configuration to determine whether the spread in the above concentrations was due to variations in aspiration rates or to analytical problems. These data are shown below.

TABLE IV

CONCENTRATION OF SODIUM CHLORIDE IN PARTICLE GENERATOR EFFLUENT

Run	μg NaCl/M^3
8	2845
8A	2870
9	3124
9A	3124

These data suggest that the variance shown in Table III was due to variations in aspiration rates. Repeated washings of the membrane filters utilized to adsorb the generator effluent showed that the initial water wash quantitatively removed the salt.

Test 2

To determine the efficiency of a membrane filter for removing sodium chloride from an aerosol the effluent from the particle generator was passed through two 0.45μ membrane filters placed in series. Data from this test are shown in Table V.

TABLE V

SODIUM CHLORIDE CONTENT OF SERIES SAMPLES OF PARTICLE GENERATOR EFFLUENT

	Sample Size	Flow Rate	μgNaCl/M³ Primary	μgNaCl/M³ Backup
(a)	100 L	10 L/min	3683	<2.5
	100 L	10 L/min	3251	<2.5
(b)*	300 L	5 L/min	1029	<2.5
	300 L	5 L/min	1054	<2.5

*Aspiration rate lowered on particle generator.

The above data indicate that the first membrane filter quantitatively removed sodium chloride from the air stream.

Test 3

A portion of the generator effluent (5 L/min) was routed through a membrane filter and then through a gas scrubber containing 150 ml of deionized water for a period of one hour to determine if any of the sodium chloride was contained in particles too small to be removed by the membrane filters. a 0.25μ filter was utilized since 0.45μ pads were not available for this particular test. Data obtained on the test are shown in Table VI.

TABLE VI

SODIUM CHLORIDE CONTENT IN SERIES SAMPLES TAKEN FROM PARTICLE GENERATOR EFFLUENT

μgNaCl/M³	
Membrane Filter	Scrubber
699	36
579	23
531	46
505	7.6
655	5.1
578	28
472	33
447	10
0.5*	18*
0.5*	38*

*Blank sample obtained from laminar flow bench.

In carrying out the analytical determination the scrubber water was concentrated to 25 ml because the concentration of sodium was too low for direct analysis. Since blank samples drawn through the membrane filter showed essentially the same sodium chloride content in the scrubber as did contaminated samples, it was concluded that the water was either contaminated or that a contaminant was being introduced during the concentration process. In either event, it appeared that no significant amount of sodium chloride passed through the membrane filter.

Test 4

To determine the purity of the laboratory's deionized water and to clarify results obtained in Test 3, samples of water were taken on consecutive days, concentrated from 150 ml to 25 ml and analyzed for sodium. Results obtained on this test are shown in Table VII.

TABLE VII

SODIUM CHLORIDE IN DEIONIZED WATER CONCENTRATED FROM 150 ml TO 25 ml

	Set #1	
#1	15.0	μgNaCl/150 ml
#2	20.0	"
#3	11.0	"
#4	30.0	"
#5	38.0	"
	Set #2	
#1	13.0	"
#2	18.0	"
#3	9.6	"
#4	29.0	"
#5	43.0	"
#6	33.0	"

Data shown in Table VII indicate the sodium chloride content of laboratory deionized water to be 0.15 PPM. Although this concentration is considered acceptable for general laboratory usage, it is sufficient to account for the results in Table VI.

Test 5

To determine the effect of flow rate on the salt-trapping ability of a membrane filter, 60 minute samples were taken on the beach through membrane filters at rates of 5, 10 and 13 liters per minute. The filters containing the samples were rinsed with 25 ml of deionized water and analyzed for sodium by atomic absorption. Data for this test are shown in Table VIII.

TABLE VIII

SODIUM CHLORIDE CONTENT OF THE ATMOSPHERE DETERMINED BY SAMPLING WITH 0.45μ MEMBRANE FILTER PAD AT VARYING FLOW RATES

Flow Rate (L/min)	μg NaCl/M^3*	Total Sample Volume
13	18	780 L
10	17	600 L
5	28	300 L

*Average results for four determinations.

Following acquisition of the above data, analyses performed on individual membrane filter pads showed a total of 1.0 to 1.3 μg of sodium chloride per pad. This contamination level, coupled with the concentration of sodium chloride in deionized water (∿0.15 μg/ml) becomes more significant as the sample volume decreases. For example, with a 25 ml rinse the inherent contamination ($\sim$4.9 μg NaCl) would amount to 35% of the total NaCl for a 780 liter sample and 58% for a 300 liter sample. To alleviate this problem in subsequent tests all pads were boiled, decanted, reboiled and then vacuum-dried prior to use. This process reduced the sodium chloride level down to a maximum of 0.5 μg per pad. To further minimize this problem the volume of water utilized to wash a pad was reduced to 10 ml, the sample flow rate increased to 15 L/min and the sample time standardized at 2 hours.

Test 6

To measure the precision of the aerosol sampling/analysis method, duplicate samples were taken at ground level at Pad A and Pad B. An indication of the precision of the method is given by S_x, calculated from the difference in results for 36 pairs of duplicate analyses. Treatment of this data, given in Table IX, shows that for the aerosol sampling/analysis method, S_x = 1.3 μg NaCl/M^3.

TABLE IX

AEROSOL ANALYSIS FOR SODIUM CHLORIDE IN GROUND LEVEL ATMOSPHERE AT PAD A AND PAD B

	μg NaCl/M^3			
Date	Pad A		Pad B	
2-11	3.3	3.6	2.3	5.8
2-12	1.5	1.8	1.8	1.8
2-13	1.3	1.3	3.0	3.3
2-14	3.0	2.8	4.3	6.6
2-15	1.5	1.8	1.8	3.0
2-19	2.0	6.1	2.5	5.1
2-20	3.0	2.8	3.8	3.8
2-21	9.4	7.9	7.1	11.2
2-22	4.6	5.6	4.6	6.4
2-25	4.1	4.1	7.6	6.6
2-28	7.9	6.1	8.9	8.6
3-1	6.6	7.1	7.1	4.8
3-4	6.6	5.6	4.1	9.4
3-5	6.6	7.1	4.6	5.3
3-6	8.1	11.4	11.7	14.2
3-7	6.1	6.1	6.6	6.8
3-8	3.3	3.0	2.0	2.8
3-11	1.5	1.5	1.8	2.0
$\bar{x}$	4.5	4.7	4.8	6.0

APPENDIX II

Aerosol Test Results

The mean ($\bar{x}$) and the standard deviation of the mean ($S_{\bar{x}}$) for aerosol data are shown in Figures I, II and III for the 0, 60, and 120 meter levels of the Kennedy Space Center 150 Meter Ground Winds Tower and for the nearest corresponding levels of the LUT or MSS at Complex 39, Pad B. Data are also separated with regard to wind direction and wind speed. Tables X through XVII give the individual test results.

AEROSOL ANALYSIS FOR SODIUM CHLORIDE AT GROUND LEVEL

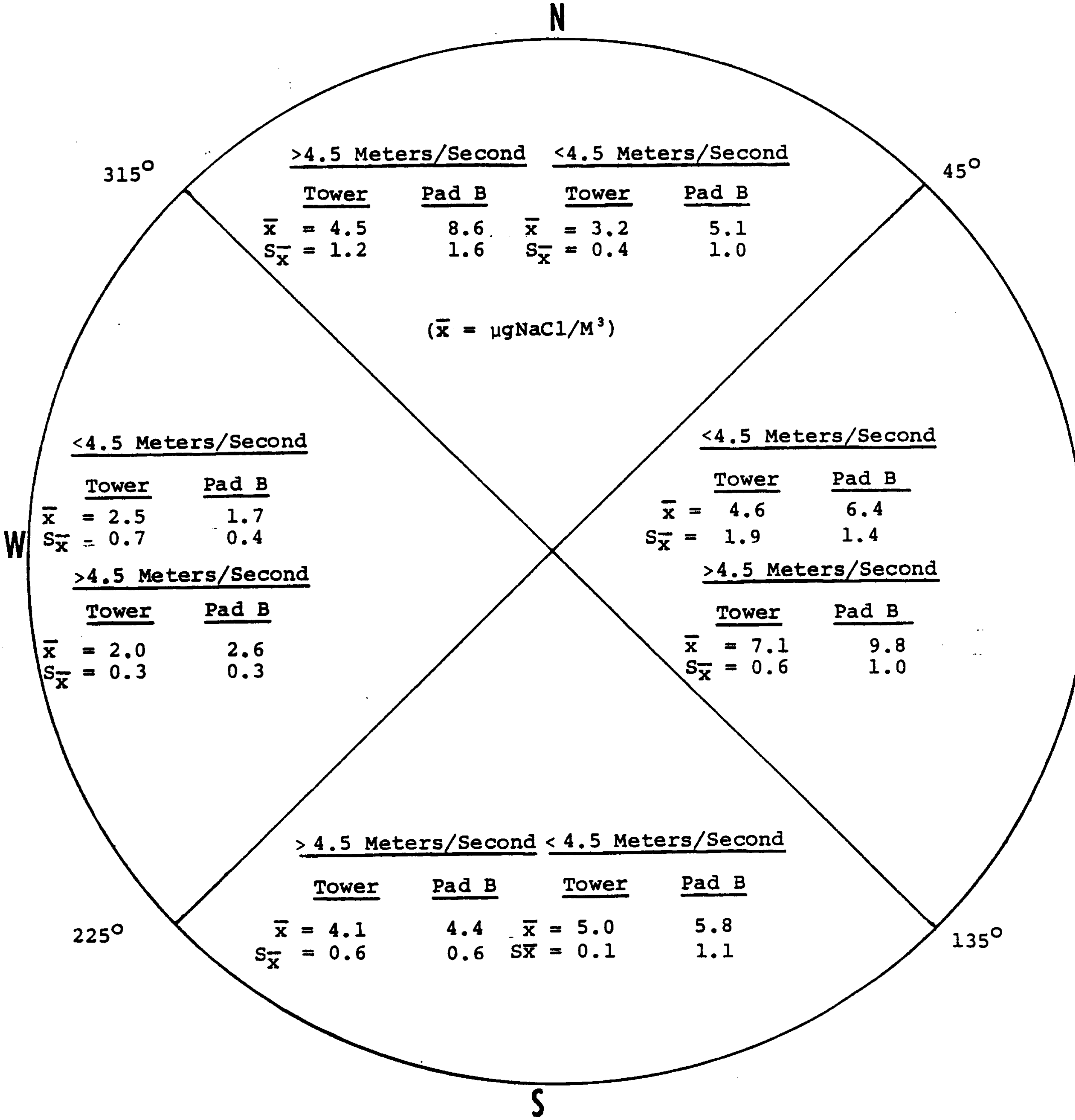
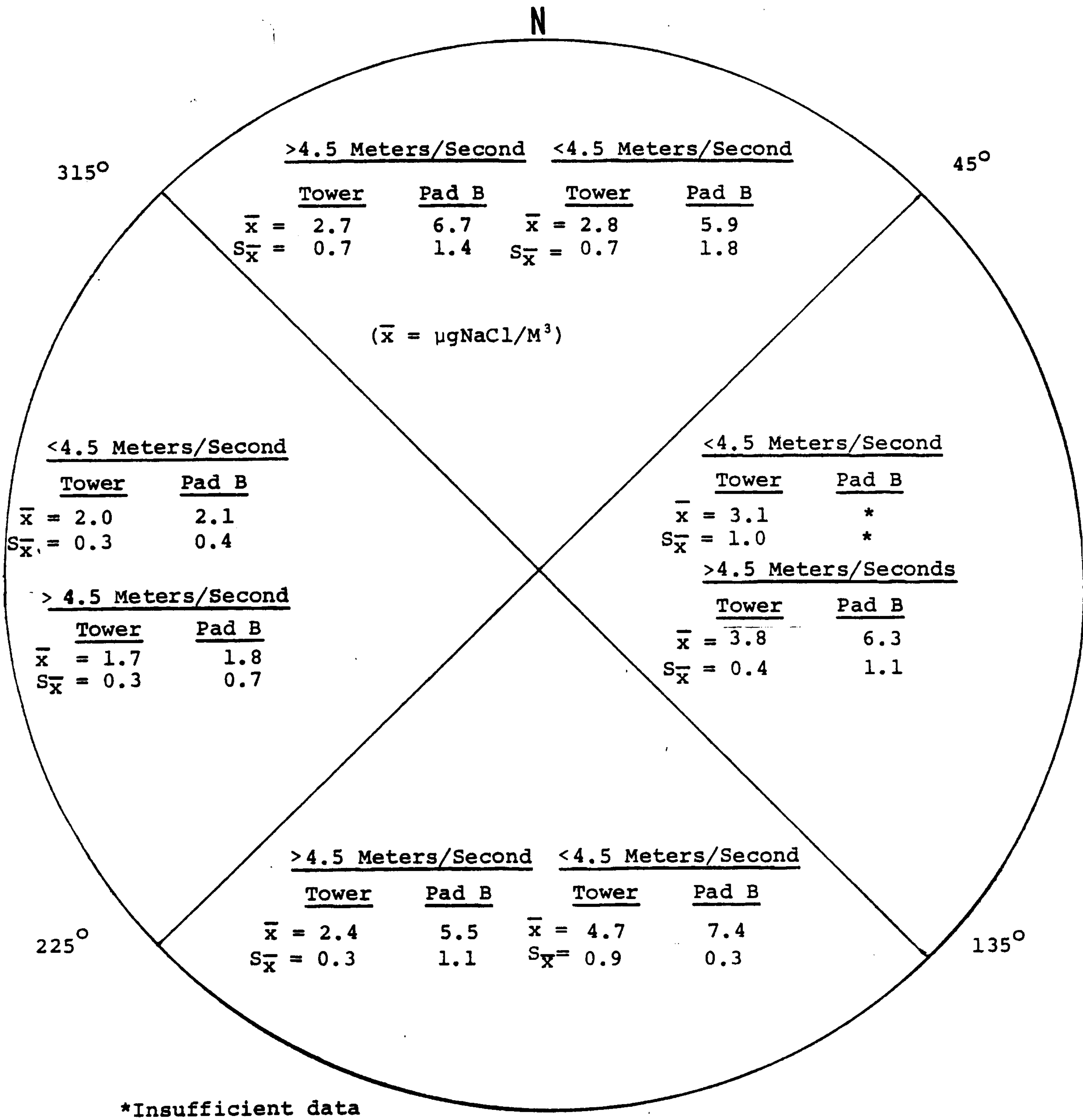


FIGURE I

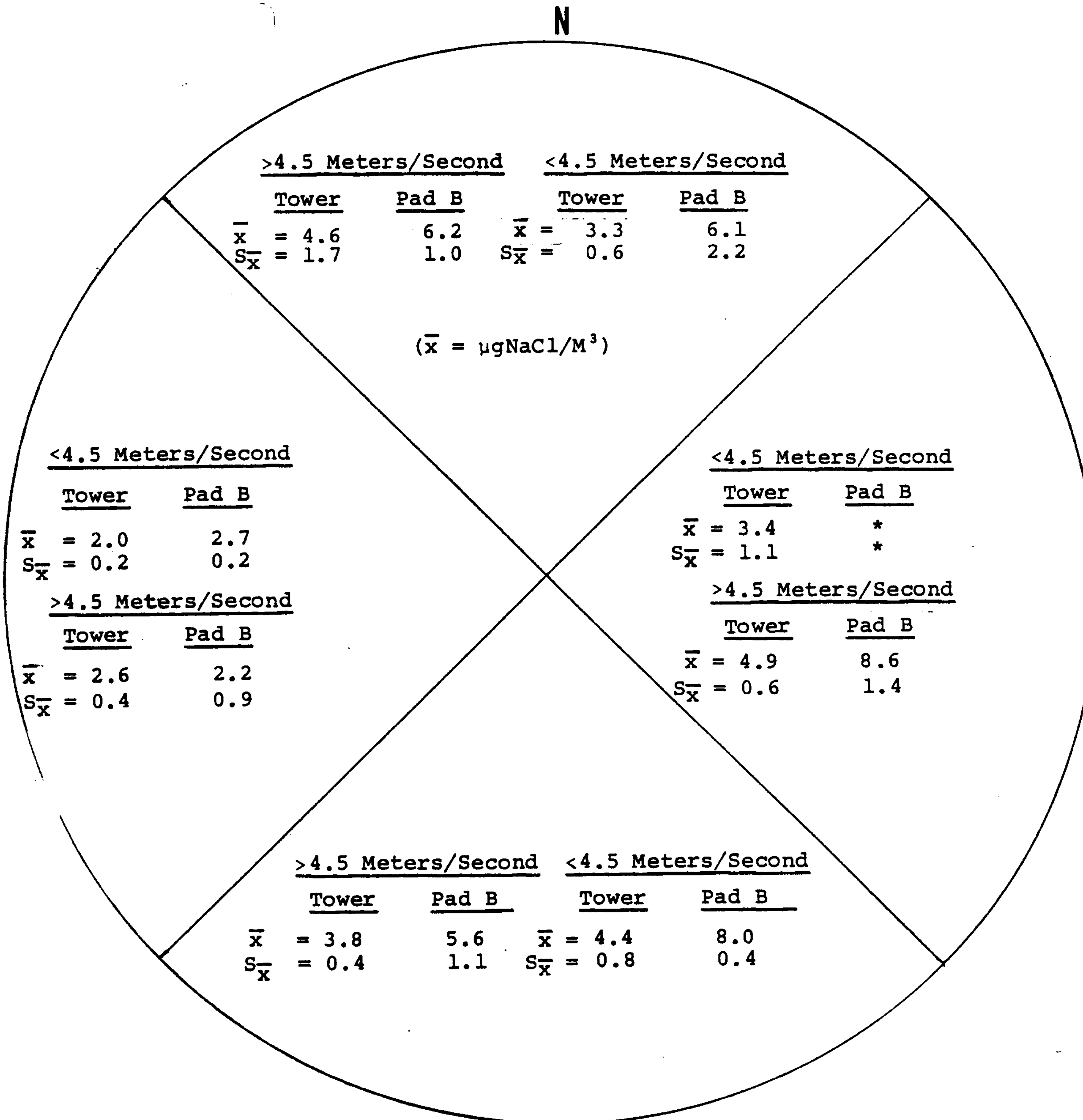
AEROSOL ANALYSIS FOR SODIUM CHLORIDE AT
60 METER AND 220 FOOT LEVELS



*Insufficient data

FIGURE II

AEROSOL ANALYSIS FOR SODIUM CHLORIDE AT
120 METER AND 360 FOOT LEVELS



*Insufficient
Data

FIGURE III

TABLE X (Cont'd)
NORTH WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower ($\mu g NaCl/M^3$)	Aerosol Pad B ($\mu g NaCl/M^3$)
2-27 AM	0	3.3	15.5
	30	2.3	
	60	1.8	
	90	2.5	
	120	6.6	
3-13 AM		2.5	5.3
		4.8	2.8
		2.0	3.8
		2.0	4.5
		2.3	5.8
3-13 PM		5.3	14.0
			6.8
			5.5
			12.0
			7.1
3-26 PM		16.0	
		13.0	
		8.4	
		12.0	
		21.0	

TABLE X

Aerosol Data

NORTH WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower ($\mu gNaCl/M^3$)	Aerosol Pad B ($\mu gNaCl/M^3$)
1-18 PM	0	3.3	3.6
	30	2.5	3.0
	60	2.5	3.6
	90	2.8	1.8
	120	2.8	3.3
2-4 AM		1.3	2.8
		3.0	3.3
		0.2	3.0
		0.5	5.8
		2.3	11.0
2-4 PM		1.5	5.6
		2.3	17.0
		0.2	11.0
		1.0	17.0
		1.0	7.6
2-5 AM		3.0	14.0
		6.6	14.0
		2.8	8.1
		4.6	6.6
		5.1	3.8
2-5 PM		8.9	15.0
		2.0	11.0
		4.3	12.0
		5.8	10.0
		6.1	5.1
2-11 PM		3.8	9.4
		1.8	
		2.3	
		0.5	
		0.5	
2-12 AM		2.5	1.8
		2.0	
		1.8	
		2.8	
		1.0	
2-25 PM		2.5	7.1
		4.8	
		3.6	
		2.0	
		2.3	

TABLE XI

NORTH WIND <4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower (μg NaCl/M³)	Aerosol Pad B (μg NaCl/M³)
1-15 AM	0	3.3	8.1
	30	4.6	12.0
	60	5.3	14.0
	90	4.6	19.0
	120	5.3	16.0
1-16 AM		5.8	11.0
		12.0	12.0
		8.4	8.4
		11.0	13.0
		8.4	8.1
1-17 AM		1.5	1.8
		1.0	2.8
		0.8	2.3
		1.8	1.8
		1.5	1.3
1-17 PM		3.3	3.6
		2.3	5.1
		3.0	3.8
		2.8	2.5
		2.3	3.8
1-18 AM		3.3	3.8
		1.3	4.3
		0.5	3.0
		1.3	2.0
		1.5	2.0
2-1 PM		3.8	4.8
		4.0	4.3
		2.5	4.1
		3.3	2.5
		4.1	5.3
2-12 PM		2.8	2.5
		3.0	
		2.0	
		2.8	
		2.3	
2-14 PM		2.3	3.0
		2.0	
		2.0	
		1.3	
		2.0	

TABLE XI (Cont'd)

NORTH WIND <4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower	Aerosol Pad B
3-1 AM	0	4.1	7.1
	30	4.3	
	60	3.3	
	90	4.6	
	120	4.6	
3-27 AM		1.5	
		5.3	
		0.5	
		2.0	
		1.5	
3-27 PM		4.1	
		3.5	
		2.8	
		2.8	
		3.3	

TABLE XII

EAST WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower (μgNaCl/M^3)		Aerosol Pad B (μgNaCl/M^3)	
1-14 AM	0	8.1		15.0	
	30	2.8		8.4	
	60	-		9.1	
	90	10.0		8.6	
	120	9.9		8.6	
1-24 PM		4.8		3.8	
		3.0		5.1	
		-		6.4	
		1.3		9.4	
		2.0		6.1	
2-6 AM		8.6		4.8	
		4.3		9.9	
		4.1		9.6	
		2.0		10.0	
		2.0		11.0	
2-21 AM/PM		5.3	8.9	7.9	9.1
		5.3	4.8		
		5.3	4.6		
		1.5	3.3		
		3.6	4.6		
2-28 AM		6.6		11.0	13.0
		5.1			
		2.3			
		2.3			
		4.3			
3-4 AM/PM		7.4	2.5	6.0	6.8
		5.3	3.0		
		2.3	3.0		
		2.5	2.5		
		2.5	3.6		
3-5 PM		5.3		7.6	
		3.6			
		2.8			
		2.0			
		3.8			
3-6 PM		6.8		7.9	
		4.1			
		3.8			
		3.3			
		4.8			

TABLE XII (Cont'd)

EAST WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower ($\mu gNaCl/M^3$)		Aerosol Pad B	
3-7 PM	0	5.1		6.7	
	30	3.3			
	60	2.5			
	90	3.0			
	120	4.1			
3-14 AM/PM		8.4	13.0	16.0	12.0
		7.1	11.0		
		5.8	7.1	5.3	
		5.3	8.1		
		7.4	9.6		
3-15 AM/PM		7.6	8.1	13.0	16.0
		4.0	4.6		
		2.5	2.8	3.0	4.6
		3.3	5.1		
		5.1	5.6		

TABLE XIII

EAST WIND <4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower (μgNaCl/M³)	Aerosol Pad B (μgNaCl/M³)
1-15 PM	0	13.0	13.0
	30	9.4	9.9
	60	6.4	11.0
	90	6.3	9.6
	120	7.4	9.1
1-22 PM		5.1	9.1
		4.6	8.8
		4.6	7.9
		4.0	5.8
		4.1	5.1
2-14 AM		0.2	1.3
		0.8	
		0.5	
		0.5	
		0.8	
3-7 AM		5.3	8.6
		4.0	
		4.3	
		4.8	
		5.3	
3-8 AM		1.0	2.5
		0.8	
		0.8	
		0.2	
		0.5	
3-8 PM		2.8	3.6
		2.3	
		1.8	
		2.0	
		2.0	

TABLE XIV

SOUTH WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower ($\mu g NaCl/M^3$) AM	Tower PM	Pad B AM	Pad B PM
1-21	0	3.8	4.8	1.8	3.0
	30	1.8	8.0	1.5	3.3
	60	1.5	1.8	2.8	2.8
	90	1.8	7.1	2.5	5.6
	120	2.5	3.0	2.3	2.8
1-28		6.6	4.8	6.8	7.6
		10.0	4.5	7.8	11.0
		4.6	3.6	7.9	14.0
		2.8	2.0	9.6	-
		5.1	3.6	10.0	12.0
1-30		5.6	3.3	6.8	4.3
		5.3	4.6	3.5	2.8
		5.6	4.3	6.4	3.8
		5.3	5.3	5.6	4.3
		5.3	5.3	9.1	4.3
2-6			7.6		9.6
			6.1		12.0
			4.3		12.0
			2.3		14.0
			2.8		12.0
2-7		12.0	6.8	8.1	7.1
		4.8	7.1	7.1	5.6
		2.3	3.0	12.0	7.4
		2.8	3.8	11.0	7.1
		7.4	6.4	12.0	6.8
2-8			7.9		4.3
			2.3		2.8
			4.6		5.8
			1.0		5.3
			7.4		7.1
2-13			1.0		3.2
			1.5		
			1.0		
			0.8		
			2.0		
2-19		5.3	1.5	5.3	3.8
		2.3	1.0		
		0.5	1.0		
		0.2	1.8		
		2.0	2.8		

TABLE XIV (Cont'd)

SOUTH WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol (μgNaCl/M^3) Tower AM	Tower PM	Pad B AM	Pad B PM
2-22	0	2.3	1.5	4.5	6.8
	30	3.0	5.3		
	60	1.8	3.6		
	90	2.0	3.0		
	120	3.3	5.1		
3-19		1.0	1.5	1.5	1.0
		5.1	1.5	1.3	1.8
		1.8	1.0	2.5	1.5
		1.5	0.8	2.5	1.8
		2.3	1.0	2.5	1.8
3-20		0.5		0.2	
		0.5		0.2	
		0.5		2.0	
		3.5		0.2	
		-		0.2	
3-21		0.2	1.8	0.5	1.0
		0.2	7.8	-	-
		0.2	1.5	0.5	1.8
		4.0	1.8	0.5	1.3
		0.2	2.3	0.5	1.3
3-25		1.5	4.6		
		0.5	3.5		
		0.2	3.0		
		1.0	4.0		
		1.8	3.8		
3-26		8.1			
		3.8			
		3.3			
		2.0			
		7.1			

TABLE XV

SOUTH WIND <4.5 M/sec

DATE	Sample Point (Meters)	Aerosol (μgNaCl/M³) Tower AM	Tower PM	Pad B AM	Pad B PM
1-16	0		4.6		-
	30		5.1		7.6
	60		7.1		7.4
	90		4.0		7.6
	120		5.8		7.6
1-24		4.3		5.1	
		2.8		5.8	
		3.0		7.1	
		2.3		8.1	
		3.0		7.1	
1-25		3.3	4.6	5.1	4.1
		2.8	4.3	6.1	5.8
		3.3	3.8	6.4	6.8
		5.1	1.5	9.4	7.6
		2.3	3.3	9.9	7.1
1-29		4.8	11.0	7.1	7.1
		5.3	13.0	6.1	6.1
		3.8	9.6	8.1	8.4
		3.3	8.1	8.1	7.8
		4.3	9.4	7.6	8.4
3-5		4.6		4.6	
		4.6			
		4.6			
		4.0			
		3.6			
3-6		7.1		12.0	
		7.3			
		6.4			
		5.1			
		5.8			
3-11		1.0		1.5	
		2.0			
		1.0			
		1.5			
		2.5			

TABLE XVI

WEST WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower ($\mu gNaCl/M^3$)	Aerosol Pad B
2-11 AM	0	1.3	0.9
	30	2.3	
	60	0.5	
	90	1.0	
	120	1.3	
2-13 AM		1.8	1.8
		1.7	
		1.5	
		1.5	
		1.8	
2-15 AM		2.0	3.0
		2.3	
		2.8	
		3.8	
		5.1	
2-15 PM		4.1	3.7
		3.8	
		3.3	
		2.8	
		4.3	
2-20 AM		1.8	3.7
		1.8	
		0.8	
		1.3	
		1.0	
2-20 PM		3.0	3.8
		2.8	
		2.5	
		2.5	
		2.3	
2-25 AM		2.0	3.2
		2.0	
		1.8	
		1.8	
		3.6	
2-26 AM/PM		1.5 1.3	1.3 4.3

TABLE XVI (Cont'd)

WEST WIND >4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower (μgNaCl/M^3)	Aerosol Pad B (μgNaCl/M^3)
3-12 AM	0	1.5	1.0
	30	1.8	-
	60	1.3	1.0
	90	1.5	1.8
	120	1.8	1.0
3-12 PM		0.5	1.3
		1.3	-
		0.5	0.3
		1.0	0.8
		1.5	0.3
3-18 AM		1.3	2.3
		1.5	1.5
		1.0	2.5
		2.3	2.3
		3.6	3.8
3-18 PM		3.8	3.6
		2.8	3.0
		2.5	3.3
		5.1	5.0
		2.9	3.6

TABLE XVII

WEST WIND <4.5 M/sec

Date	Sample Point (Meters)	Aerosol Tower (μgNaCl/M³)	Aerosol Pad B (μgNaCl/M³)
1-22 AM	0	4.1	0.2
	30	1.8	0.8
	60	1.3	1.5
	90	1.3	2.0
	120	2.0	2.5
1-23 AM		0.5	1.3
		2.8	1.5
		1.0	1.3
		1.0	2.8
		1.8	2.8
1-23 PM		-	2.5
		7.3	3.3
		2.3	3.3
		1.8	4.0
		1.8	3.6
2-1 AM		3.6	2.5
		4.8	3.0
		2.0	2.8
		3.0	1.0
		2.0	2.5
3-20 PM		1.3	1.8
		3.5	1.8
		2.0	1.8
		2.0	2.3
		2.0	2.3
3-28 AM		3.0	
		3.8	
		3.3	
		2.8	
		2.8	

APPENDIX III

Fallout Method Development

A number of tests were carried out to obtain information on the efficiency of steel plates and pans of deionized water as sodium chloride fallout collectors, on the precision of the test results, and on various factors influencing the test results.

Test 1

Two methods of collection were employed to establish a means of measuring the amount of sodium chloride fallout from the atmosphere: a dry stainless steel plate with a surface area of one square foot and a one square foot pan of like material containing 300 ml of deionized water. Fallout samplers were exposed to the atmosphere for a specific period of time (usually 6 hours). At the conclusion of the test period the plates were rinsed with deionized water and the rinse and the deionized water from the pan sample analyzed for sodium. To measure the precision of the fallout sampling/analysis methods and to obtain comparative data on the methods, duplicate samples were taken at ground level at Pad A and Pad B. Treatment of this data, given in Table XVIII, shows that for the plate method $\overline{x}$ = 201 μg $NaCl/M^2/hr$ and S_x = 54 and that for the pan method $\overline{x}$ = 234 μg $NaCl/M^2/hr$ and S_x = 63. From the results in Test 1 it was concluded that the plate and pan methods produce essentially equivalent data. The plate method was adopted for the remainder of the fall-out tests because it was the more convenient of the two methods.

TABLE XVIII

PLATE AND PAN ANALYSES FOR SODIUM CHLORIDE IN GROUND LEVEL ATMOSPHERE AT PAD A AND PAD B

	Plate (μgNaCl/M^2/hr)*				Pan (μgNaCl/M^2/hr)*			
Date	Pad A		Pad B		Pad A		Pad B	
2-11	140	108	215	140	108	161	161	108
2-12	108	55	108	108	82	108	108	82
2-13	140	82	194	194	161	82	161	269
2-14	140	140	161	194	194	140	140	140
2-15	82	55	108	140	82	82	248	248
2-19	248	248	269	495	387	409	441	301
2-20	215	194	140	140	248	215	140	161
2-21	248	194	323	215	215	215	441	323
2-22	161	161	194	140	323	215	301	194
2-25	301	269	269	301	201	269	215	355
3-1	495	549	441	689	517	323	624	872
3-5	161	108	215	194	194	140	215	194
3-6	194	140	194	161	269	194	269	269
3-7	194	140	194	301	194	161	-	269
3-8	140	82	108	140	140	161	-	-
3-11	194	82	194	194	269	140	215	215
$\overline{x}$	198	163	208	234	230	188	263	267

*All results based on exposures of six hours.

Test 2

To determine if fallout of salt was continuous or reached equilibrium after a period of a few hours, tests were conducted by exposing seven plates on the beach and removing and analyzing one each hour. These data are shown in Table XIX.

TABLE XIX

PLATE EXPOSURE TEST TO DETERMINE RATE OF SALT BUILD UP

	3/25/74 South Wind >4.5 M/sec		3/26/74* South/North >4.5 M/sec		3/27/74 North Wind >4.5 M/sec		3/28/74 West Wind >4.5 M/sec		3/29/74 West Wind >4.5 M/sec	
Elapsed Time (Hr.)	µg NaCl/M^2	µg NaCl/M^2/hr	µg NaCl/M^2	µg NaCl/M^2/hr	µg NaCl/M^2	µg NaCl/M^2/hr	µg NaCl/M^2	µg NaCl/M^2/hr	µg NaCl/M^2	µg NaCl/M^2/hr
1	247	247	14359	14359	15306	15306	926	926	495	495
2	161	81	14768	7384	28707	14354	926	463	495	247
3	161	54	15586	5195	66435	22145	2131	710	657	219
4	872	218	12034	3008	57963	14491	3391	848	764	191
5	2734	547	34175	6835	69718	13944	6835	1367	818	164
6	323	54	60148	1025	77102	12850	13121	2187	657	110
7	1722	246	71713	10253	94733	13533	21054	3008	570	81

*Foggy during sample period

These data are sufficiently variable that they are felt to be inconclusive in establishing that fallout on a test plate is cumulative. Consideration of possible sources of these variations suggested that contamination in positioning the plates and carrying out the analytical determinations introduced considerable bias in the results for the shorter periods.

Test 3

Test 2 was repeated with 10 plates positioned on the 360' level of the MSS to measure accumulated salt fallout over a period of several days. One plate, used as a control, was flushed daily, excluding weekends, then repositioned and allowed to remain until the following work day. Data obtained on these tests are in Table XX.

TABLE XX

PLATE EXPOSURE TEST TO DETERMINE RATE OF SALT BUILD UP

Wind (Degrees-M/sec) 0600	Wind (Degrees-M/sec) 1400	Precipitation (Inches)	CONTROL PLATE µg NaCl/M^2	CONTROL PLATE Exposure Time (Hours)	CONTROL PLATE µg NaCl/M^2/hr	TEST PLATE µg NaCl/M^2	TEST PLATE Exposure Time (Hours)	TEST PLATE µg NaCl/M^2/hr
280-3.6	320-5.1	-	8471	24	353			
220-2.6	230-5.6	0.34	6017	72	84	9074	96	94
290-1.5	40-5.1	trace	5630	24	235	5134	120	43
10-1.0	90-6.1	0.05	9601	24	400	10333	144	72
Calm	90-5.1	0.04	7933	24	330	17384	168	103
200-3.6	160-6.1	-	11205	24	467	26081	192	136
320-4.6	360-5.6	-	31215	72	434	12626	264	48
130-5.1	110-6.1	trace	21269	24	886	24692	288	86
220-4.6	140-7.6	0.05	17685	24	737	43174	312	138
160-4.1	140-7.6	0.05	25424	24	1059	44293	336	132

Due to measurable precipitation on seven of the fourteen test days, data in Table XX are difficult to interpret. In addition, the daily control samples may have been biased due to transfer of contaminants from the bottom of the plate during the rinsing process.

Test 4

Test 4 was carried out using ten (10) plates positioned for a six-day exposure at various elevations on the weather tower and on the MSS. No precipitation occurred during the six-day test period. Wind direction and speed obtained at noon each day were as follows:

Day	Direction	Speed
4/26/74	53°	6.1 M/sec
4/27/74	88°	7.1 "
4/28/74	105°	7.6 "
4/29/74	81°	5.6 "
4/30/74	45°	1.5 "
5/1/74	29°	4.6 "

Data obtained on analyzing the plates after six days are shown in Table XXI.

TABLE XXI

SIX-DAY EXPOSURE TEST TO DETERMINE RATE OF SALT BUILD UP

Sample Point	μg NaCl/M^2	μg NaCl/M^2/hr
Weather Tower 0 meters	12303	85
" " 30 "	19278	134
" " 60 "	22970	160
" " 90 "	18040	125
" " 120 "	25973	180
MSS 0 feet	28438	197
MSS 90 " (∿30 meters)	37458	260
MSS 180 " (∿60 meters)	31990	222
MSS 310 " (∿100 meters)	24337	169
MSS 360 " (∿120 meters)	22421	156

Wind direction during 5 of the 6 days during test 4 was from the east and, as expected, data obtained showed higher concentrations of salt than obtained in Test 3.

Test 5

In order to better understand the data obtained in Tests 2 and 3 and to further determine the extent of the initial high bias on fallout samples, a controlled test was performed in an assumed "no salt" environment. Test plates were positioned in laminar flow benches located in the laboratory and allowed to remain for a 16-hour period prior to rinsing and analysis. These plates were given identical treatment to those utilized in Table XVIII. Data obtained on these tests are shown in Table XXII.

TABLE XXII

ANALYSIS FOR SALT ON PLATES EXPOSED TO A CONTROLLED ENVIRONMENT

Plate #	μg $NaCl/M^2$	μg$NaCl/M^2/hr$
1	1830	114
2	624	39
3	355	22
4	1152	72
5	603	38
6	2131	133
7	624	39
8	215	13
9	850	53
10	1227	77
11	2626	164
12	1884	118

The data in Table XXII indicate a definite bias in the sampling results due to an uncorrected blank. This bias becomes less significant when a large quantity of salt is present on the plate. Therefore, only the long exposure (days) test results were used to calculate the average salt fallout given in the conclusion portion of the report.